Subject: AIA Comments on NIST NCSTAR 1 (World Trade Center)
From: "Goldberg, Andrew" <AGoldberg@aia.org>
To: <wtc@nist.gov>
Cc: "Faucheux, Ron" <RFaucheux@aia.org ...snip... TWolfe@aia.org>,
<pregrp@aol.com>

Dear Sir or Madam:

Attached are The American Institute of Architects' comments on the draft Final Report of the National Construction Safety Team on the Collapses of the World Trade Center Towers (NIST NCSTAR 1).

If you have any questions, please do not hesitate to contact me at the phone number or email address below.

Sincerely,

Andrew Goldberg, Assoc. AIA
Manager, Federal Regulatory Activities
The American Institute of Architects
1735 New York Avenue, N.W.
Washington, D.C. 20006
Tel (202) 626-7438
Fax (202) 626-7364
agoldberg@aia.org


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The American Institute of Architects

The World Trade Center Investigation

The AIA's Response to NIST's Draft Report and Recommendations

August 4, 2005

The American Institute of Architects
1735 New York Avenue, NW
Washington, DC 20006-5292
Information Central: 800-242-3837

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Introduction

The American Institute of Architects represents more than 75,000 licensed architects, emerging professionals, and allied partners who are fully committed to the highest professional standards in the design of the nation's built environment. As the AIA's public policies state, "Architecture profoundly affects people. The work of architects is essential to human well being, and architects must embrace their ethical obligation to uphold this public trust."

The AIA and its members welcome the opportunity to provide public comments on the *Final Report of the National Construction Safety Team on the Collapses of the World Trade Center Towers* (NIST NCSTAR 1). In June, the AIA invited its members to provide input to the Institute about the draft report and recommendations. These comments reflect the views expressed by the AIA's members.

The AIA intends to continue this dialogue with the architecture community and allied professions over the coming weeks and months, and will provide additional commentary to NIST about its report and recommendations.

The AIA cannot overstate the accomplishments of the NIST investigating team and the substantial body of information they gathered and organized in response to one of the worst catastrophes in American history. The results are a definitive historical record of the largest and most devastating building disaster ever. The AIA was honored to participate in this process by having one of its members serve on the National Construction Safety Team Advisory Committee.

Recognizing the superior design and performance of the twin towers during an unprecedented terrorist attack, the data that the investigating team compiled should not only help identify deficiencies but also serve as a testament to the buildings' ability to stand long enough after the attack to allow thousands of occupants to evacuate.

We owe it to the victims of the September 11 attacks, and to the millions of Americans who use buildings every day, to ensure that our built environment is safe, and that any changes to how we design and construct buildings come about as the result of an open, deliberative and rational building code and regulation development process.

General Issues

The Investigation: Demonstrating the Robustness of the Towers

On September 11, 2001, the World Trade Center towers were subjected to an almost unimaginable attack from hijacked, fuel-laden 767s flying at such high speeds that one of the jets nearly broke apart in midair. Following its Congressional authorization to investigate the circumstances that contributed to the towers' collapse, NIST lauds the success of the design, construction and materials for their exceptional performance. The report finds that the buildings would have survived the catastrophic event were it not for the fact that the aircraft caused extensive damage to the buildings and their fire protective systems (both passive and active), and ignited extensive fires that were limited only by the amount of combustible material they could reach.

The report presents, in its Executive Summary, the following findings regarding the design, construction and materials of the towers:

1. *...the towers withstood the impacts and would have remained standing were it not for the dislodged insulation (fireproofing) and the subsequent multifloor fires. The robustness of the perimeter frame-tube system and the large size of the buildings helped the towers withstand the impact. The structural system redistributed loads without collapsing in places of aircraft impact, avoiding larger scale damage upon impact.*

2. *The WTC towers likely would not have collapsed under the combined effects of aircraft impact damage and the extensive, multifloor fires if the thermal insulation had not been widely dislodged or had been only minimally dislodged by aircraft impact.*

3. *Since the flow of people from the building had slowed considerably 20 min* [sic] *before the tower* [WTC 1] *collapsed, the stairwell capacity was adequate to evacuate the occupants on that morning.*

4. *As in WTC 1, shortly before collapse, the flow of people from the building* [WTC 2] *had slowed considerably, indicating that the stairwell capacity was adequate that morning.*

5. *The fire safety systems (sprinklers, smoke purge, and fire alarms,) were*

designed to meet or exceed current practice.

6. *For the approximately 1,000 emergency responders on the scene, this was the largest disaster they had even seen. Despite attempts by the responding agencies to work together and perform their own tasks, the extent of the incident was well beyond their capabilities.*

7. *... the actual design and approval process produced two buildings that generally were consistent with nearly all of the provisions of the New York City Building Code and other building codes of the time. The loads for which the buildings were designed exceeded the code requirements. The quality of the structural steels was consistent with the building specifications. The departures from the building codes and standards did not have a significant effect on the outcome of September 11.*

8. *On September 11, 2001, the minimum specified thickness of the insulation was adequate to delay heating of the trusses; the amount of insulation dislodged by the aircraft impact, however, was sufficient to cause the structural steel to be heated to critical levels*

9. *.... in all cases* [during NIST's testing of fire rated assemblies], *the floors continued to support the full design load without collapse for over 2 hours.*

10. *The wind loads used for the WTC towers, which governed the structural design of the external columns and provided the baseline capacity of the structures to withstand abnormal events such as major fires or impact damage, significantly exceeded the requirements of the New York City Building Code and selected other building codes of the day.*

The North Tower. The first account of the performance of World Trade Center 1(the north tower) is found in Chapter 2 of NIST's final report. Following a detailed description of the extent of damage, the report states, "Even with all this damage, the building still stood." Ignition of the building contents by the explosion of 10,000 gallons of jet fuel is addressed in the account of WTC 1, which finds that the ignition of the contents of the building and airplane caused a fuel-controlled fire, creating an exposure that is not typical of any condition that is considered when designing buildings.

The report finds that the aircraft impact virtually destroyed the fire protection systems. The report states that the system was designed to supply water to about eight sprinkler heads at one time, enough to control the flames from as much as 1,500 square feet of burning material. The water supply was likely sufficient to control fires up to triple that size. However, the fires caused by

the aircraft impact were far larger than those envisioned by any imaginable fire protection system.

The South Tower. World Trade Center 2 (the south tower) was subjected to a similar event, but faced a number of factors that were distinct from WTC 1. Those factors resulted in a larger overall fraction of the occupants surviving, despite the fact that WTC 2 collapsed in a shorter period of time. According to the report, within five minutes of the impact on WTC 1, half of the occupants of WTC 2 had left their floors, and the number of evacuees subsequently increased rapidly. Based on their perception of events occurring in WTC 1, approximately 3,000 people in WTC 2 escaped in the 16 minutes between the aircraft impact on WTC 1 and the impact on WTC 2.

The report goes on to state that WTC 2 "swayed more than one foot back and forth in each direction on the impact floors, about one-third the sway under the high winds for which the building was designed." Nonetheless, just like WTC 1, WTC 2 absorbed the aircraft strike and remained standing for nearly an hour. Similar to the circumstances of WTC 1, jet fuel played a critical role in providing an extraordinary ignition source to the fuel load in WTC 2, contributing to the ultimate failure of the structural system.

The World Trade Center collapse provided the design and construction industry with an opportunity to evaluate and reexamine its processes and practices. Based upon the outstanding success of these buildings under extraordinary circumstances, it is clear that the design community can be trusted to create redundancies for typical building emergency situations, that codes are developed in a manner that provides sufficient input from all quarters to ensure adequate life safety for typical emergency situations, and that no upgrading of code requirements is warranted given the performance of these buildings.

The Recommendations: Missed Opportunities

Although the report provides significant information regarding the performance of the buildings, their occupants and the extraordinary efforts of the responding emergency personnel, the AIA believes that a number of the recommendations in the report are not supported by the findings of the investigation. Other recommendations suggest reforms that have already been addressed by the design and construction industry or the model code organizations.

At the same time, the AIA believes that the report misses opportunities to make recommendations that would improve the understanding of how buildings perform in extreme events. Developing that understanding in order to protect building occupants must be a fundamental mission of all

organizations that work to create a better built environment.

One such area is fire testing. NIST developed advanced fire modeling techniques to evaluate the complex circumstances at the World Trade Center, examining the spread of fire and its impact on structural members. This may become an important tool for designing safer buildings, although their ability to integrate known conditions into the modeling currently used in the marketplace was a major problem even for NIST when it evaluated the 2003 fire at the Station nightclub in Rhode Island.

The AIA believes that improved fire testing is a vital need, and opportunity, that must not be ignored. The Institute is therefore troubled by the fact that there are no test facilities in the United States that can accommodate the larger lengths or sizes of elements such as those found in the twin towers. If the federal government is truly committed to understanding the effects of such fire hazards on the built environment, it is critical that it provide for adequate testing facilities at home.

The AIA strongly encourages NIST to recommend that funding be authorized and appropriated to construct new testing facilities or retrofit existing facilities that can address the full range of building conditions present in the United States.

In addition, NIST should be encouraged to take advantage of its position as the preeminent research facility in the United States to examine innovative materials and processes and assure that they meet the most rigorous of standards appropriate for their use. Performance codes, which the AIA believes are the future direction for building codes and regulations, are sorely in need of supporting information on the actual performance of buildings and building systems. Without this data, designers are left to make assumptions based on limited resources.

Furthermore, the AIA believes that NIST should facilitate opportunities to develop "smart" building systems that would better advise first responders of actual building conditions and situations. The current efforts to improve the use of elevators in an emergency are an example of the dramatic changes that will take place to the guidance provided to building occupants.

Building Codes: An Accountable and Comprehensive System

The major finding of the NIST report is that the design and construction materials of the World Trade Center did not contribute to the disaster; they performed exceptionally well. Despite this fact, the report offers several recommendations that are not supported by the investigation, nor are they

backed by substantive research. In fact, the premises of some of the statements appear to be in error.

For example, in section 9.1 ("Building Standards and Codes: Who is in Charge?"), the report states, "Very few members of the general public and building occupants participate in [the code development] process." Although this is true of most standards development groups, including NFPA and IAPMO, it is not true for the International Code Council's family of codes. State and local code enforcement officials (building, fire, plumbing, electrical, etc.) are a driving force behind code changes and have the controlling votes on all changes to ICC's codes. These officials are public officials who represent their states, counties and cities, and do not fall within any of the categories that NIST lists as "influencing the practices used in the design, construction, operation, and maintenance of buildings in the United States."

The code enforcement community has been extraordinarily aggressive in pursuing education and certification for their members. Many states and local jurisdictions have worked diligently to assure the credibility of their enforcement programs by requiring certification of training obtained by their code enforcement officials.

The question of "who is in charge" regarding the development and application of codes and standards is well established and recognized by 45 states as the code official using the *International Building Code,* and in 36 states as the code official using the *International Fire Code.*

The AIA believes that state and local governments must retain the authority to determine appropriate building regulations. The AIA does not agree that the federal government is in a position to supplant the voice or the rights of local and state jurisdictions by presuming to speak for the public that is given the constitutional authority through police powers to determine what is appropriate for building regulation in their communities.

The fundamental challenge regarding codes and life safety today is the lack of an understanding or an appreciation by users of the safety features designed and built into modern buildings. This includes building owners, managers, tenants and service providers who often unintentionally subvert life safety features out of ignorance about how they work. This was most evident in the Rhode Island nightclub tragedy, where modifications that were made to the interior of the building and the use of pyrophoric materials in the facility were both major violations of the applicable codes. Had the owner or the user of the space been more knowledgeable about the potential hazards associated with such actions, that disaster would likely have been averted.

Recommendations and Responses

The report states that NIST's recommendations (Section 9.2) are based on:

1. Findings related to building performance, evacuation and emergency response, and to procedures and practices used in the design, construction, operation, and maintenance of the buildings;

2. Whether these findings relate to the unique circumstances surrounding the terrorist attacks of September 11, 2001, or to normal building and fire safety considerations (including evacuation and emergency response);

3. Technical solutions that are needed to address potential risks to buildings, occupants, and emergency responders, considering both identifiable hazards and the consequences of those hazards; and

4. Whether the risks apply to all buildings or are limited to certain building types (e.g., buildings that exceed a certain height and floor area or that employ a specific type of structural system), buildings that contain specific design features, iconic/signature buildings, or buildings that house critical functions.

NIST's recommendations are broken down into eight groups. The AIA's comments follow each recommendation.

Group 1: Increased Structural Integrity

Group 1 (Increased Structural Integrity) calls for improved standards to enhance structural integrity for estimating load effects of progressive collapse and wind.

Recommendation 1. *NIST recommends that: (1) progressive collapse should be prevented in buildings through the development and nationwide adoption of consensus standards and code provisions, along with the tools and guidelines needed for their use in practice; and (2) a standard methodology should be developed—supported by analytical design tools and practical design guidance—to reliably predict the potential for complex failures in structural systems subjected to multiple hazards.*

Recommendation 2. *NIST recommends that nationally accepted performance standards be developed for: (1) conducting wind tunnel testing*

of prototype structures based on sound technical methods that result in repeatable and reproducible results among testing laboratories; and (2) estimating wind loads and their effects on tall buildings for use in design, based on wind tunnel testing data and directional wind speed data.

Recommendation 3. *NIST recommends that an appropriate criterion should be developed and implemented to enhance the performance of tall buildings by limiting how much they sway under lateral load design conditions (e.g., winds and earthquakes).*

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It should be noted that nothing in the NIST report criticizes nor questions the structural integrity of the World Trade Center towers and their design. In fact, the report finds that the buildings were more robust than would have been required by any code in force at the time they were designed and constructed. NIST's report focuses on the varying results they received when different consultants examined the buildings' wind design. It is the lack of a consensus method for evaluating buildings that NIST's recommendations address, not providing additional requirements for the design of structures.

A recent article by Jesse Beitel and Nestor Iwankiw, Ph.D., P.E., from Hughes Associates, Inc., in SFPE's *Fire Protection Engineering* (Summer 2005) documents a "Historical Survey of Multistory Building Collapses Due to Fire." The data in the article was taken from a NIST survey performed in 2002 that focused on buildings four or more stories tall. The survey covered the time period between 1970 and 2002 and discovered a total of 22 buildings that had either full or partial collapse. The article states, "While the number of fire events may appear low (average of one per year), these fire events are high-consequence occurrences with respect to loss of life, injuries, and economic costs." When examining those statistics, five of the fire events were the result of the September 11 attacks, and 13 of the buildings were four to eight stories tall. There were only three "high-rise" buildings that involved any collapse scenario.

The Beitel/Iwankiw article states:

> Almost 60 percent (13/22) of the cases are in the 4-8 stories range, with the remainder affecting much taller buildings. Six collapses occurred in buildings over 20 stories, and three of these were the WTC steel-framed buildings (1, 2, and 7). At least four of these fire collapses had occurred during construction or renovations of some kind, when the usual expected architectural, structural and fire protection functions were still incomplete or temporarily disrupted.

It is common knowledge that a construction site is an unsafe and dangerous environment. Additionally, the research for this study does not include any information determining whether the buildings conformed to any code or

standard. Based on NIST's own study, it appears that the recommendation to increase structural integrity is due to fire events in a total of four collapsed structures four stories or taller over a 32-year period. Assuming that one of the collapses is the Murrah Federal Building in Oklahoma City, Oklahoma, in which the collapse was the result of a vehicle-borne explosive, this leaves a total of three such fire events worldwide that resulted in collapse or partial collapse of a high-rise building.

Group 2: Enhanced Fire Resistance of Structures

Group 2 (Enhanced Fire Resistance of Structures) recommends that the procedures and practices used to ensure that the basis for classification of fire resistance in buildings should be enhanced.

Recommendation 4. *NIST recommends evaluating, and where needed improving, the technical basis for determining appropriate construction classification and fire rating requirements (especially for tall buildings greater than 20 stories in height)—and making related code changes now as much as possible—by explicitly considering factors including:*

- *timely access by emergency responders and full evacuation of occupants, or the time required for burnout without local collapse;*
- *the extent to which redundancy in active fire protection (sprinkler and standpipe, fire alarm, and smoke management) systems should be credited for occupant life safety;*
- *the need for redundancy in fire protection systems that are critical to structural integrity;*
- *the ability of the structure and local floor systems to withstand a maximum credible fire scenario without collapse, recognizing that sprinklers could be compromised, not operational, or non-existent;*
- *compartmentation requirements (e.g., 12,000 ft^2) to protect the structure, including fire rated doors and automatic enclosures, and limiting air supply (e.g., thermally resistant window assemblies) to retard fire spread in buildings with large, open floor plans;*
- *the impact of spaces containing unusually large fuel concentrations for the expected occupancy of the building; and*
- *the extent to which fire control systems, including suppression by automatic or manual means, should be credited as part of the prevention of fire spread.*

Recommendation 5. *NIST recommends that the technical basis for the century-old standard for fire resistance testing of components, assemblies, and systems should be improved through a national effort. Necessary guidance also should be developed for extrapolating the results of tested assemblies to prototypical building systems.*

Recommendation 6. *NIST recommends the development of criteria, test methods, and standards: (1) for the in-service performance of spray-applied fire resistive materials (SFRM, also commonly referred to as fireproofing or insulation) used to protect structural components; and (2) to ensure that these materials, as-installed, conform to conditions in tests used to establish the fire resistance rating of components, assemblies, and systems.*

Recommendation 7. *NIST recommends the nationwide adoption and use of the "structural frame" approach to fire resistance ratings.*

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Enhanced fire resistance was not an issue in the World Trade Center collapse, as the buildings would have survived even the massive fires caused by the aircraft had the planes not dislodged fire proofing materials.

Recommendation 4 implies that structures should be designed for an aircraft impact, which does not comport with NIST's findings. In fact, the lead investigator for NIST has stated that it is far easier to ensure that airplanes are not used as weapons against buildings than to design for such an event. As noted earlier, the instances of structural failure due to fire are extremely rare and, in a fully sprinklered building, even rarer. These facts do not indicate a need for enhanced levels of fire resistance in building design.

One of the concerns expressed with regard to construction methods involves the application of spray-on fireproofing. This debate is not new and has been well documented. It is of concern that, with such a large focus in the report on the fire resistance of materials used in the buildings, there is no mention of the appropriateness of test standards such as **ASTM E605-00** (*Test Method for Thickness and Density of Sprayed Fire-resistive Material (SFRM) Applied to Structural Members) and* **ASTM E736** (*Cohesion/Adhesion of Sprayed Fire-Resistive Materials Applied to Structural Members)*, both of which are referenced in the *International Building Code*, and thus presumably "required by code" and enforced.

Similarly lacking is reference to, or a measure of the appropriateness of, **ASTM E759** (*Effect of Deflection on Sprayed Fire-Resistive Materials Applied to Structural Members)*, **ASTM E760** (*Effect of Impact on Bonding of Sprayed Fire-Resistive Materials Applied to Structural Members)*, **ASTM E761** (*Compressive Strength of Sprayed Fire-Resistive Materials Applied to Structural Members)*, **ASTM E859** (*Air Erosion of Sprayed Fire-Resistive Materials Applied to Structural Members)*, or **ASTM E937** (*Corrosion of Steel by Sprayed Fire-Resistive Materials Applied to Structural Members*).

In recommendation 5, NIST suggests reevaluation of the ASTM E119 procedure. The AIA believes that a better approach would be to take the research performed by NIST using recognized testing procedures to explore how the large-scale testing compares with results obtained using small-scale

tests. The fact that the unrestrained assembly outperformed the restrained assembly is still unexplained. It appears that design is still taking place under the assumption that a restrained assembly will outperform an unrestrained assembly.

NIST specifically refers to the AIA in recommendation 6, suggesting that it is important "to develop criteria, test methods and standards for the 'in-service' performance of spray-applied fire resistive materials." NIST suggests that MasterSpec is the appropriate forum for such activity. Architects in general, and MasterSpec in particular, do not have that sole responsibility establishing such standards. Other agencies or organizations develop standards, which are then included in MasterSpec where appropriate as requirements for the construction of buildings. Architects and specifiers often participate in the development of standards, which is appropriate to assure the applicability of the resulting standards. But it is the collaborative development of standards that should be encouraged. With the lack of specific direction on the use of the standards that even now are found in building codes, it is unclear what NIST is recommending be done.

Lastly, recommendation 6 suggests adoption of a structural frame approach to design throughout the United States. However, the requirement for design of a structural frame has already been accomplished by the adoption of the *International Building Code* in 45 states.

Group 3: New Methods for Fire Resistance Design of Structures

Group 3 (New Methods for Fire Resistance Design of Structures) recommends that procedures used to design the fire resistance should be enhanced by considering uncontrolled fires to burnout. This recommendation suggests that new coatings and technology for evaluating them be developed to enhance conventional and high-performance structural materials.

Recommendation 8. *NIST recommends that the fire resistance of structures should be enhanced by requiring a performance objective that uncontrolled building fires result in burnout without local or global collapse.*

Recommendation 9. *NIST recommends the development of: (1) performance-based standards and code provisions, as an alternative to current prescriptive design methods, to enable the design and retrofit of structures to resist real building fire conditions, including their ability to achieve the performance objective of burnout without structural or local floor collapse: and (2) the tools, guidelines, and test methods necessary to evaluate the fire performance of the structure as a whole system.*

Recommendation 10. *NIST recommends the development and evaluation of new fire resistive coating materials, systems, and technologies with significantly enhanced performance and durability to provide protection*

following major events.

Recommendation 11. *NIST recommends that the performance and suitability of advanced structural steel, reinforced and pre-stressed concrete, and other high-performance material systems should be evaluated for use under conditions expected in building fires.*

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Recommendation 8 suggests consideration of designing to allow "uncontrolled fires to burnout." Such circumstances may be a consideration, but are not appropriate in most circumstances. Even where there have been uncontrolled fires that caused a "burnout," there is no evidence that current procedures are inadequate. In the article by Beitel and Iwankiw, which uses NIST data, the rationale is not present to warrant such a major change in building code requirements.

Recommendation 9 reflects actions taken by both the ICC and the NFPA in the development of performance code criteria. What is currently lacking are the tools and background information on responses of buildings and the performance of the elements within them for any given event. The AIA believes that NIST could provide a significant resource to the industry by examining actual fire scenarios more closely and developing guidelines for understanding such events. With that kind of data available, designers would be able to utilize a performance approach to building safety that is informed by real world evidence.

The AIA questions the logic behind recommendations 10 and 11. The report frequently expresses doubt about "innovative" design materials and methods in its evaluation of the floor truss systems in the World Trade Center. Yet those innovative floor framing systems performed as anticipated and were proven to be adequate based on the tests that NIST performed. Industry will continuously develop innovative materials and systems, and the AIA believes that NIST can and should play a vital role in encouraging them by facilitating more realistic testing that would replicate actual construction.

Group 4: Improved Active Fire Protection

Group 4 (Improved Active Fire Protection) calls for enhancements to sprinklers, standpipes, hoses, fire alarms and smoke management systems, including redundancy.

Recommendation 12. *NIST recommends that the performance and redundancy of active fire protection systems (sprinklers, standpipes/hoses, fire alarms, and smoke management systems) in buildings should be enhanced to accommodate the greater risks associated with increasing building height and population, increased use of open spaces, available compartmentation, high-risk building activities, fire department response limits, transient fuel loads, and higher threat profile.*

Recommendation 13. *NIST recommends that fire alarm and communications systems in buildings should be developed to provide continuous, reliable, and accurate information on the status of life safety conditions at a level of detail sufficient to manage the evacuation process in building fire emergencies, and that standards for their performance be developed.*

Recommendation 14. *NIST recommends that control panels at fire/emergency command stations in buildings should be adapted to accept and interpret a larger quantity of more reliable information from the active fire protection systems that provide tactical decision aids to fireground commanders, including water flow rates from pressure and flow measurement devices, and that standards for their performance be developed.*

Recommendation 15. *NIST recommends that systems should be developed and implemented for: (1) real-time off-site secure transmission of valuable information from fire alarm and other monitored building systems for use by emergency responders, at any location, to enhance situational awareness and response decisions and maintain safe and efficient operations; and (2) preservation of that information either off-site or in a black box that will survive a fire or other building failure for purposes of subsequent investigations and analysis. Standards for the performance of such systems should be developed, and their use should be required.*

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NIST's concerns about the redundancy of active and passive fire protective systems are valid in circumstances where *all* such systems may be rendered ineffective or inoperative. However, such circumstances are extremely rare, as was the case in the unprecedented aircraft attack on the World Trade Center. The *ICC Performance Code for Buildings and Facilities,* NFPA's 101 *Life Safety Code* and 5000 *Building Code* already include this approach to fire protection design in their performance guidelines. Although the World Trade Center was not designed for such complex circumstances, it nevertheless performed remarkably well.

Recommendations 13, 14, and 15 include opportunities for significant improvement in the performance of fire protection systems by installing smart building devices. Where there is a reasonable risk of natural or manmade hazards to a particular structure, every effort should be taken to ensure the security of the facilities and protection of the occupants.

Group 5 (Improved Building Evacuation) addresses communications systems and the design of means of egress.

Recommendation 16. *NIST recommends that public agencies, non-profit organizations concerned with building and fire safety, and building owners*

Group 5: Improved Building Evacuation

and managers should develop and carry out public education campaigns, jointly and on a nationwide scale, to improve building occupants' preparedness for evacuation in case of building emergencies.

Recommendation 17. *NIST recommends that tall buildings should be designed to accommodate timely full building evacuation of occupants due to building-specific or large-scale emergencies such as widespread power outages, major earthquakes, tornadoes, hurricanes without sufficient advanced warning, fires, accidental explosions, and terrorist attack. Building size, population, function, and iconic status should be taken into account in designing the egress system. Stairwell and exit capacity should be adequate to accommodate counterflow due to emergency access by responders.*

Recommendation 18. *NIST recommends that egress systems should be designed: (1) to maximize remoteness of egress components (i.e., stairs, elevators, exits) without negatively impacting the average travel distance; (2) to maintain their functional integrity and survivability under foreseeable building-specific or large-scale emergencies; and (3) with consistent layouts, standard signage, and guidance so that systems become intuitive and obvious to building occupants during evacuations.*

Recommendation 19. *NIST recommends that building owners, managers, and emergency responders develop a joint plan and take steps to ensure that accurate emergency information is communicated in a timely manner to enhance the situational awareness of building occupants and emergency responders affected by an event. This should be accomplished through better coordination of information among different emergency responder groups, efficient sharing of that information among building occupants and emergency responders, more robust design of emergency public address systems, improved emergency responder communication systems, and use of the Emergency Broadcast System (now known as the Integrated Public Alert and Warning System) and Community Emergency Alert Networks.*

Recommendation 20. *NIST recommends that the full range of current and next generation evacuation technologies should be evaluated for future use, including protected/hardened elevators, exterior escape devices, and stairwell navigation devices, which may allow all occupants an equal opportunity for evacuation and facilitate emergency response access.*

Recommendation 16, though well intentioned, misses a key element of building safety. While ensuring proper egress during an emergency is important, too many building owners, managers and occupiers fail to prepare for emergencies before the fact. Examples of malfunctioning or failed systems (such as burned out exit sign lights or fire doors that are blocked by furniture or boxes) are routine, leaving occupants in jeopardy. It is therefore just as important to educate users about maintaining the many life safety elements in

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a building so that they are functioning as designed when an emergency happens.

Recommendation 17 suggests wider stairwells and greater exit capacity to accommodate regarding counter-flow from first responders. This raises a concern about orderly and controlled egress. No research is cited regarding the effect wider stairs may have, or the possibility that evacuating occupants will simply fill the larger stairwell. Faster-moving individuals will tend to pass slower people descending the stairs, potentially leading to conflict and disruption of an orderly egress process.

Regarding the distribution of exits, the current model codes address the minimum remoteness issue. Had the stairs been more remote from each other at the World Trade Center there is no guarantee that even hardened stair enclosures would not have been totally incapacitated had the aircraft impacted the buildings at or near the more remote stair. Placing stairs further outside the core of buildings reduces their level of hardening and leaves them more vulnerable to abuse by the occupants of the building.

Recommendation 20 calls for hardening of elevators and stairway enclosures as well as additional devices that aid egress. Unfortunately, the hardening issue can be a catch-22. Although hardening may help in maintaining an element's viability in certain emergency situations, the hardened features may be difficult for occupants to manage if they are damaged. Reports have emerged about individuals caught inside elevators at the twin towers who used various devices to escape by cutting their way through the drywall shaft. Would that have been possible in a hardened shaft? Furthermore, the occupants who discovered the single stair that remained partially open to the upper floors in WTC 2 would not have been able to remove "hardened" debris and egress those stairs.

Technology for aids to egress are encouraged. However the most promising development to assist egress in a tall building is a functioning elevator system, as proven in WTC 2.

Group 6 (Improved Emergency Response) recommends technical and procedural changes to gain access to buildings and maintain effective communications and command and control in large-scale emergencies

Recommendation 21. *NIST recommends the installation of fire-protected and structurally hardened elevators to improve emergency response activities in tall buildings by providing timely emergency access to responders and allowing evacuation of mobility-impaired building occupants. Such elevators should be installed for exclusive use by emergency responders during emergencies. In tall buildings, consideration also should be given to*

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installing such elevators for use by all occupants.

Recommendation 22. *NIST recommends the installation, inspection, and testing of emergency communications systems, radio communications, and associated operating protocols to ensure that the systems and protocols: (1) are effective for large-scale emergencies in buildings with challenging radio frequency propagation environments; and (2) can be used to identify, locate, and track emergency responders within indoor building environments and in the field.*

Recommendation 23. *NIST recommends the establishment and implementation of detailed procedures and methods for gathering, processing, and delivering critical information through integration of relevant voice, video, graphical, and written data to enhance the situational awareness of all emergency responders. An information intelligence sector should be established to coordinate the effort for each incident.*

Recommendation 24. *NIST recommends the establishment and implementation of codes and protocols for ensuring effective and uninterrupted operation of the command and control system for large-scale building emergencies.*

Recommendation 21 largely duplicates recommendation 20. Existing elevator technology recalls all elevators for emergency use. Whether hardening is appropriate is a serious question; it has not been proven to be appropriate or even desirable in those locations where it has been attempted.

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Group 7 (Improved Procedures and Practices) addresses code compliance by nongovernmental agencies, adoption of egress and sprinkler requirements in codes for existing buildings and maintenance of building documents over the life of the structure.

Group 7: Improved Procedures and Practices

Recommendation 25. *Nongovernmental and quasi-governmental entities that own or lease buildings and are not subject to building and fire safety code requirements of any governmental jurisdiction are nevertheless concerned about the safety of the building occupants and the responding emergency personnel. NIST recommends that such entities should be encouraged to provide a level of safety that equals or exceeds the level of safety that would be provided by strict compliance with the code requirements of an appropriate governmental jurisdiction. To gain broad public confidence in the safety of such buildings, NIST further recommends that it is important that as-designed and as-built safety be certified by a qualified third party, independent of the building owner(s). The process should not use self-approval for code enforcement in areas including interpretation of code provisions, design approval, product acceptance,*

certification of the final construction, and post-occupancy inspections over the life of the buildings.

Recommendation 26. *NIST recommends that state and local jurisdictions should adopt and aggressively enforce available provisions in building codes to ensure that egress and sprinkler requirements are met by existing buildings. Further, occupancy requirements should be modified where needed (such as when there are assembly use spaces within an office building) to meet the requirements in model building codes.*

Recommendation 27. *NIST recommends that building codes should incorporate a provision that requires building owners to retain documents, including supporting calculations and test data, related to building design, construction, maintenance and modifications over the entire life of the building. Means should be developed for offsite storage and maintenance of the documents. In addition, NIST recommends that relevant building information should be made available in suitably designed hard copy or electronic format for use by emergency responders. Such information should be easily accessible by responders during emergencies.*

Recommendation 28. *NIST recommend that the role of the "Design Professional in Responsible Charge" should be clarified to ensure that: (1) all appropriate design professionals (including, e.g., the fire protection engineer) are part of the design team providing the standard of care when designing buildings employing innovative or unusual fire safety systems, and (2) all appropriate design professionals (including, e.g., the structural engineer and the fire protection engineer) are part of the design team providing the standard of care when designing the structure to resist fires, in buildings that employ innovative or unusual structural and fire safety systems.*

AIA Response

Recommendations 25 and 26 call for the adoption and use of codes. The AIA has long advocated that every jurisdiction in the nation, at all levels of government, to use a modern building code that is comprehensive, coordinated and contemporary. The AIA believes that the ICC family of codes, in conjunction with the NFPA electrical code, provide the "bookshelf" of codes that should be endorsed by all legislative and quasi-legislative agencies for application on all projects. Adoption of a single "bookshelf" of codes utilized by all designers, builders and operators of buildings across the nation has been a long sought goal of the AIA to avoid confusion in the creation of the built environment.

Recommendation 28 calls for the "design professional in responsible charge" to assure that the appropriate professionals are included on each design team. This is, and has been for a long time, standard practice in this country and is demanded by the licensing criteria in all states. There appears to be a

presumption that fire protection engineers and structural engineers are somehow excluded from "innovative or unusual fire safety systems." It is most likely that these designers are the ones who are proposing innovative solutions to innovative designs. It would be unethical and unprofessional to fail to include a fire protection engineer or structural engineer in such projects.

Group 8: Education and Training

Group 8 (Education and Training) calls for the skills of building and fire professionals to be upgraded through education and training of fire protection engineers, structural engineers, and architects

Recommendation 29. *NIST recommends that continuing education curricula should be developed and programs should be implemented for training fire protection engineers and architects in structural engineering principles and design, and training structural engineers, architects, and fire protection engineers in modern fire protection principles and technologies, including fire-resistance design of structures.*

Recommendation 30. *NIST recommends that academic, professional short-course, and web-based training materials in the use of computational fire dynamics and thermostructural analysis tools should be developed and delivered to strengthen the base of available technical capabilities and human resources.*

AIA Response

Recommendations 29 and 30 call for education of members of the design and construction industry. As the only professional organization in the industry that holds its members to a standard of education (accredited degrees) and continuing education (18 hours of continuing education per year, of which at least eight must be related to health, safety and welfare), the AIA applauds NIST's call to others in the field to gain additional education.

However, education is only valuable if the information is readily understood and can be incorporated into every-day practice. While computational fire dynamics and thermostructural analysis tools may be helpful in certain circumstances, they must be of use to those that will make the decisions associated with fire resistance and fire protection and design.

Conclusion

NIST has undertaken an extraordinary effort to investigate and understand the consequences of the most devastating terrorist attack in our nation's history. It should be reassuring to the public that the report concludes that World Trade Center towers were well within the contemporary norms of design and construction, and that the buildings were able to stand long enough to allow thousands of people to escape.

But the terrible loss of life that day demands that we study the results of this investigation closely to learn what the design and construction professions have done right, and where improvements can be made to better protect people in buildings.

The recommendations in the NIST report are useful guidelines towards that end. However, the AIA believes that at times the recommendations overlook measures and technologies that are already in practice, or go in directions that are not supported by either the investigation or scientific research.

The need to protect the health, safety and welfare of people who use buildings is not a subject of debate. This is why the AIA requires its members to adhere to the highest professional standards and take at least eight hours of health, safety and welfare continuing education classes each and every year throughout their careers in order to remain members in good standing.

The NIST report and recommendations raise powerful issues about how best to achieve building safety and security. The AIA encourages NIST to further investigate areas such as actual building occupant loads and develop data on actual building performance through additional testing of full-sized components. NIST provides an ideal platform to investigate and report fairly these issues. However, it will be necessary to gather much more data to verify any change in the direction of model building codes. The AIA continues to believe that the best way to ensure that building codes protect the public is to ensure that model codes are developed through an open, consensus based process.

The AIA commends NIST for making education a focus of its efforts. The AIA encourages the design and construction industry, and everyone who uses buildings, to take advantage of opportunities to gain a greater understanding of how buildings affect our lives and our communities.